A Review Of Technical Performance and Technology Maturity Approaches for Improved Developmental Test and Evaluation Assessment

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Outline

- Overview
- Current efforts
- Literature Review
  - Technology Maturity
  - Technical Performance Risk
- Observations
- Future Work
- Conclusion

Overview

- Purpose
  - A review of technology maturity and technical performance approaches to improve DT&E assessment
  - Discuss the mutual beneficial relationship between the SE and T&E communities
- Motivation
  - A need for a tangible means to quantitatively assess technical readiness in order to transition from DT to IOT&E

Current efforts

- The DASD(DT&E) office is working to institutionalize the process and use of metrics to improve MDAP success in entering and exiting IOT&E.
- A framework, along with an initial set of performance criteria and associated metrics, was developed.
- Effort resulted in development of 14 performance criteria

Department of Defense. (2011). DoD Developmental Test and Evaluation and Systems Engineering FY2011 Annual Report.

Performance Criteria

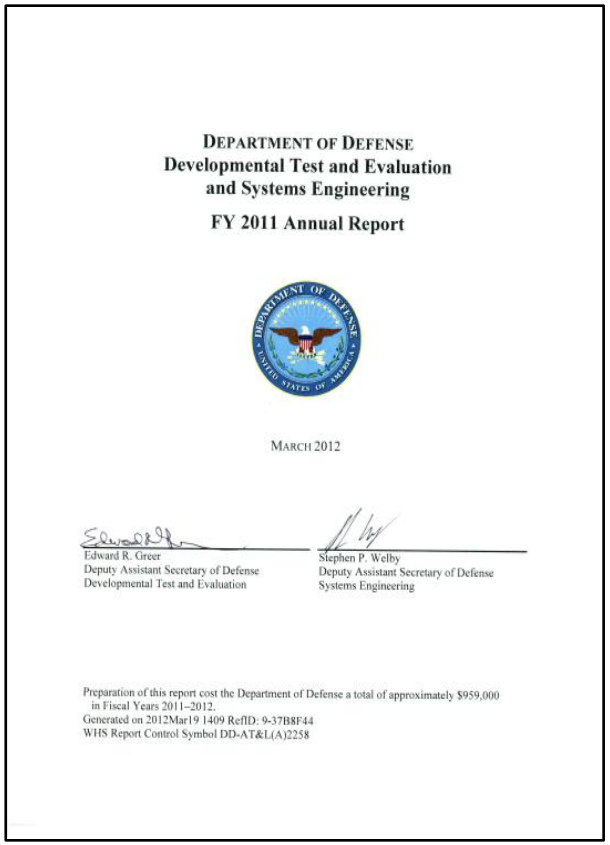
1. Key performance parameters (KPPs) are functionally traceable to Warfighter capabilities.*
2. KPPs are evaluated for mission capabilities.
3. **Establish evaluation framework for KPPs and critical technical parameters (CTPs).**
4. **Execute evaluation framework for KPPs and CTPs.***
5. **Demonstrated technical progress and system maturity.**
6. Assess safety of the system.*
7. TEMP adequacy and currency.
8. DT&E resource management.
9. DT&E phase schedule performance.
10. Adherence to T&E policy and process.*
11. T&E program effectiveness and efficiency.*
12. AOTR accuracy.
13. T&E workforce certification status.
14. Fill identified T&E KLPs.

(*) Requires further study to determine value and applicability

Department of Defense. (2011). DoD Developmental Test and Evaluation and Systems Engineering FY2011 Annual Report.

Measurable Performance Criteria

- As part of the framework, the DASD(DT&E) developed a method for assessment. For each performance criterion, the Action Officer (AO) both assesses performance against the particular criterion and provides a confidence level in making the assessment.
- For the performance assessment, the DASD(DT&E) uses the stoplight colors of green, yellow, and red. The meaning of each stoplight assessment color was developed uniquely for each criterion to reflect the proper status. A "Not Rated" assessment is also available, as appropriate.



DEPARTMENT OF DEFENSE
Developmental Test and Evaluation
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Current Confidence Assessment

- **High confidence** is assessed when the presence and maturity of program T&E artifacts and documentation is consistent with expectations at the program's point in its life cycle.
- **Medium confidence** is assessed when the presence of program T&E artifacts and documentation is consistent with expectations at the program's point in its life cycle, but detail and maturity of documentation is lacking.
- **Low confidence** is assessed when there are omissions, gaps, inconsistencies, lack of expected detail, and/or conflicting data and information observed in program T&E artifacts and documentation.

Subjective and oversimplifies performance criteria!

Department of Defense. (2011). DoD Developmental Test and Evaluation and Systems Engineering FY2011 Annual Report.

Evaluation Framework

- Establish evaluation framework for KPPs and critical technical parameters (CTPs).
- Execute evaluation framework for KPPs and CTPs.

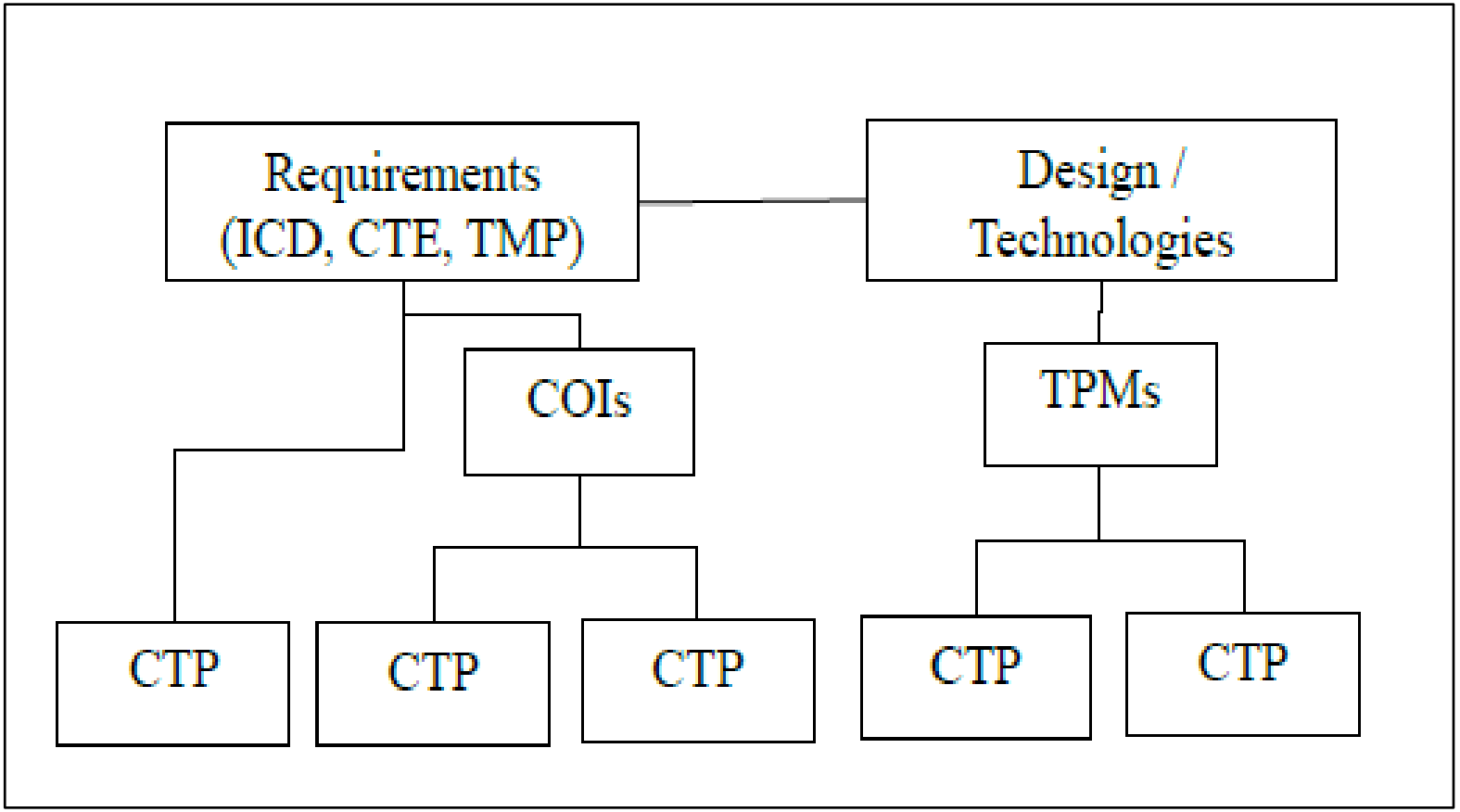
DT&E Assessment

- Assess technical progress and maturity against critical technical parameters (CTPs), key system attributes (KSAs), KPPs, and critical operational issues (COIs) as documented in the TEMP and test plans (DAU, 2012)
- CTPs can be used to assess completion of a major phase of developmental testing such as ground or flight testing; and determine readiness to enter the next phase of testing, whether developmental or operational (DAU, 2012)

Critical Technical Parameters

- **Definition:** CTPs measure critical system characteristics that, when achieved, enable the attainment of desired operational performance capabilities (DAU, 2012)
- Every technical parameter is **NOT** a CTP
- CTPs focuses on critical design features or risk areas (e.g., technical maturity, RAM issues, physical characteristics or measures) that if not achieved or resolved during development will preclude delivery of required operational capabilities (DAU, 2012)

How are CTPs derived?



CTPs can be established from CTEs, TMPs, SE, etc.

Mosser-Kerner, D. (2009). "Test & Evaluation Strategy for Technology Development Phase". Presented at NDIA Systems Engineering Conference.

Technical Progress and Maturity

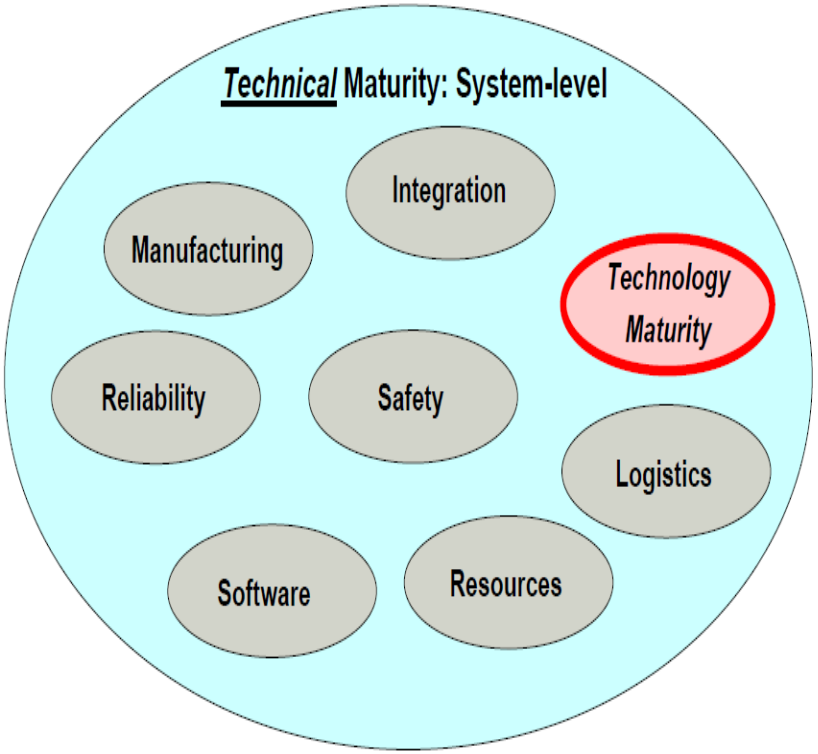
- Demonstrated technical progress and system maturity.

Problem Statement

- "Objective and robust methods that can assess technology maturity accurately and provide insight into **risks** that lead to cost overruns, schedule delays, and performance degradation are imperative for making well-informed procurement decisions." (Azizian et al, 2009)
- The Weapon System Acquisition Reform Act of 2009 recognized that "unrealistic performance expectations" and "immature technologies" are among the root causes of trouble in defense programs *(Gilmore, 2011)*
- "Reduce risk of immature technology in systems development" *(Stuckey, 2007)*
- "Programs that started development with immature technologies experienced an average acquisition unit cost increase of nearly 21 percent" (GAO-05-301, 2005)

Technical versus Technology Maturity

- Assessing the **maturity of a particular technology** involves determining its **readiness** for operations across a spectrum of environments with a final objective of transitioning it to the user. Application to an acquisition program also includes determining the fitness of a particular technology to meet the customer's requirements and desired outcome for operations (MITRE, 2012)



Technology Maturity is a component- or subsystem-level issue

Stuckey, R. (2007). "OSD DT&E Perspective: Technology Development and Maturation", Presented at AFRL Technology Maturity Conference.

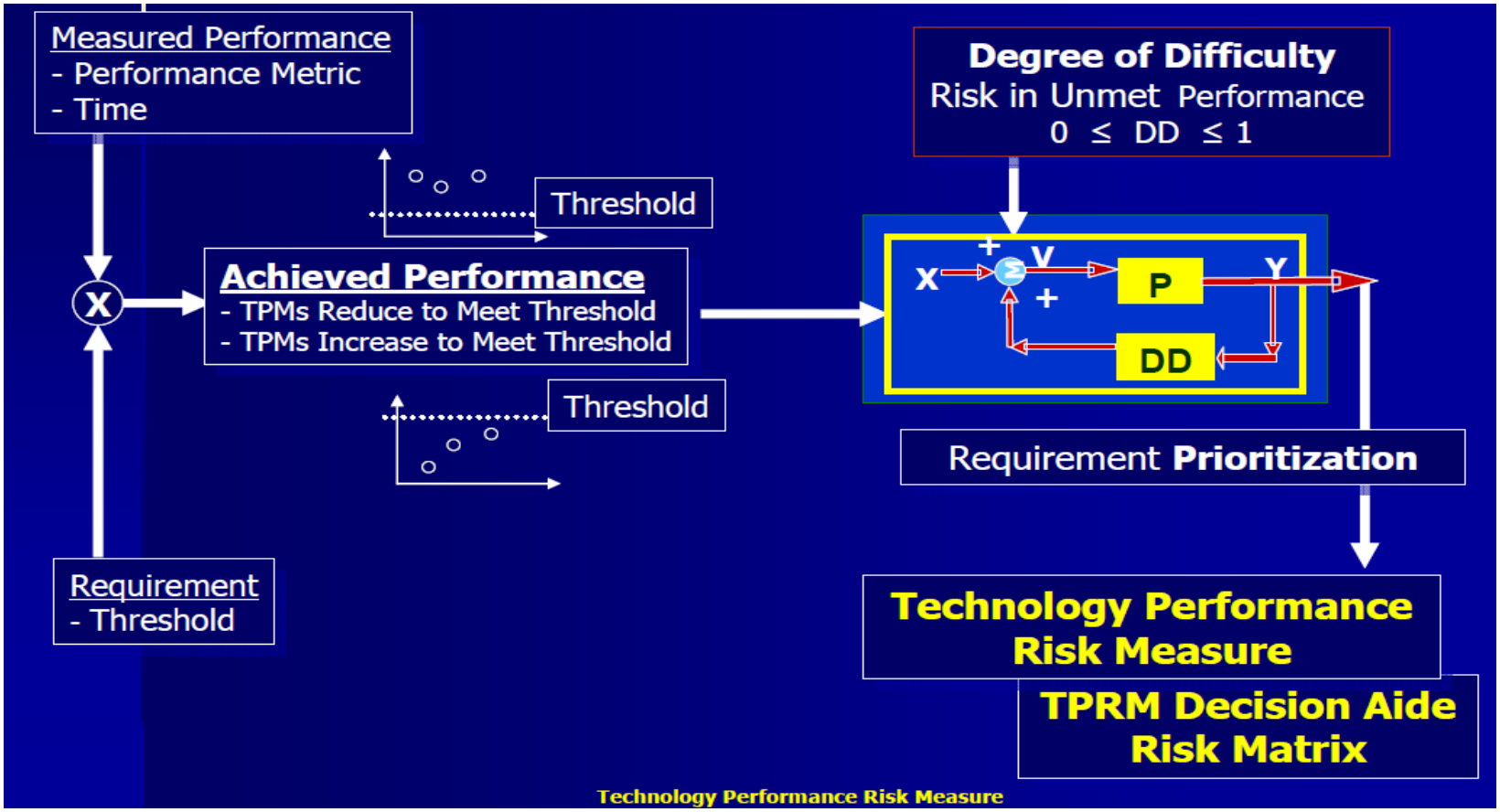
Technology Maturity

- Immature technology is a primary source of cost and schedule risk (Stuckey, 2007)
- Recommendation was to add technology maturity focus into the SE and DT&E processes (Stuckey, 2007)
  - TRL verification
- Not recommended due to numerous TRL limitations (Azizian et al, 2009)
  - Subjective
  - Focused on hardware
  - Lacks accuracy and precision
  - Not focused on system-to-system integration
  - Does not communicate difficulty of maturing technology to higher TRL levels
  - Increasing complexity of defense systems

Technical Performance Risk

- Little is available on how to integrate technical performance measures into a meaningful measure of system's overall performance risk (Garvey and Cho, 2003)
  - 2003: Developed a Performance Risk Index Measure
  - 2004: Extended previous work to measure and monitor a System-of-Systems' Performance Risk
- TRLs does not measure how well the technology is performing against a set of performance criteria (Mahafza, 2005)
  - 2006: Developed Technology Performance Risk Measure

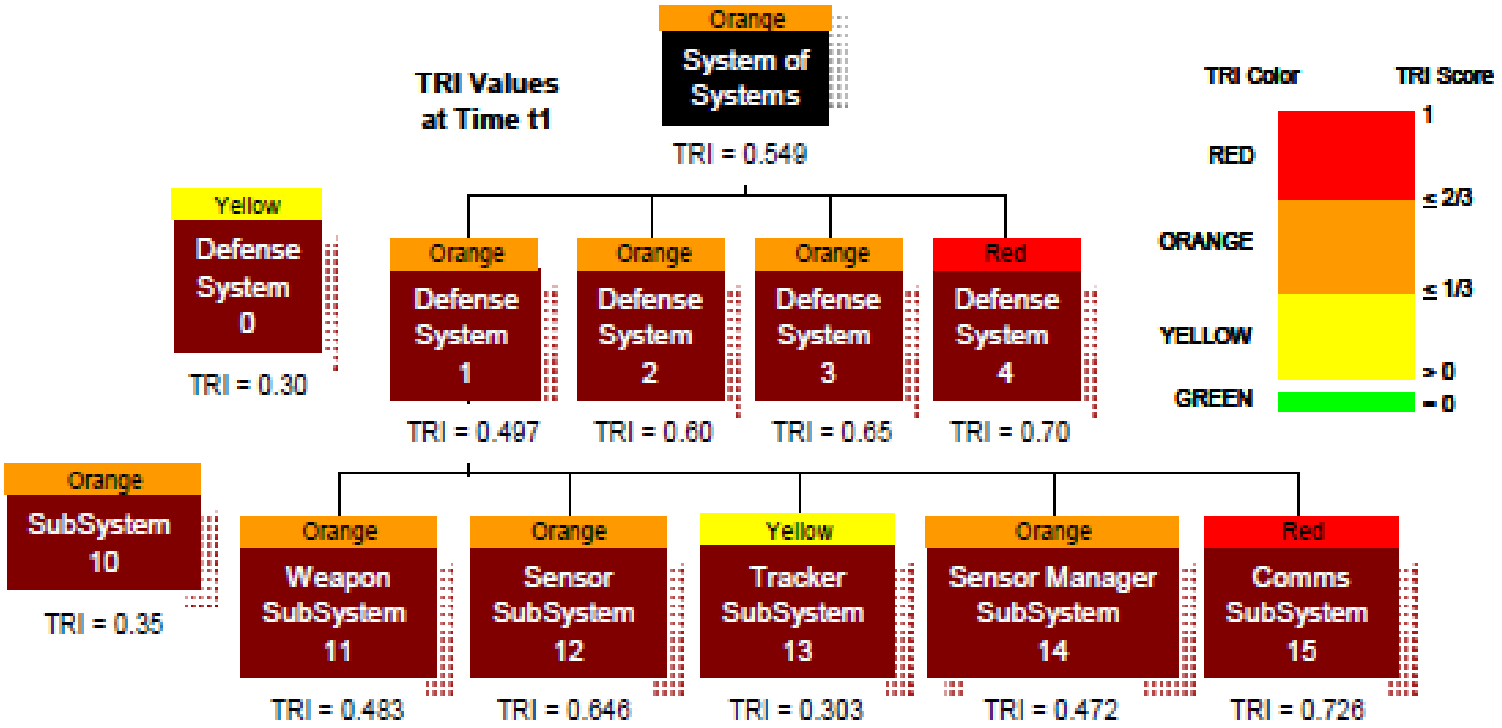
Technology Performance Risk Measure



- Measures performance risk of technology in order to determine transition readiness
- Computed using performance requirements, the DD, and unmet performance

Mahafza, S. (2004). "Technology Performance Risk Measure". Presented at Multi-Dimensional Assessment of Technology Maturity Workshop.

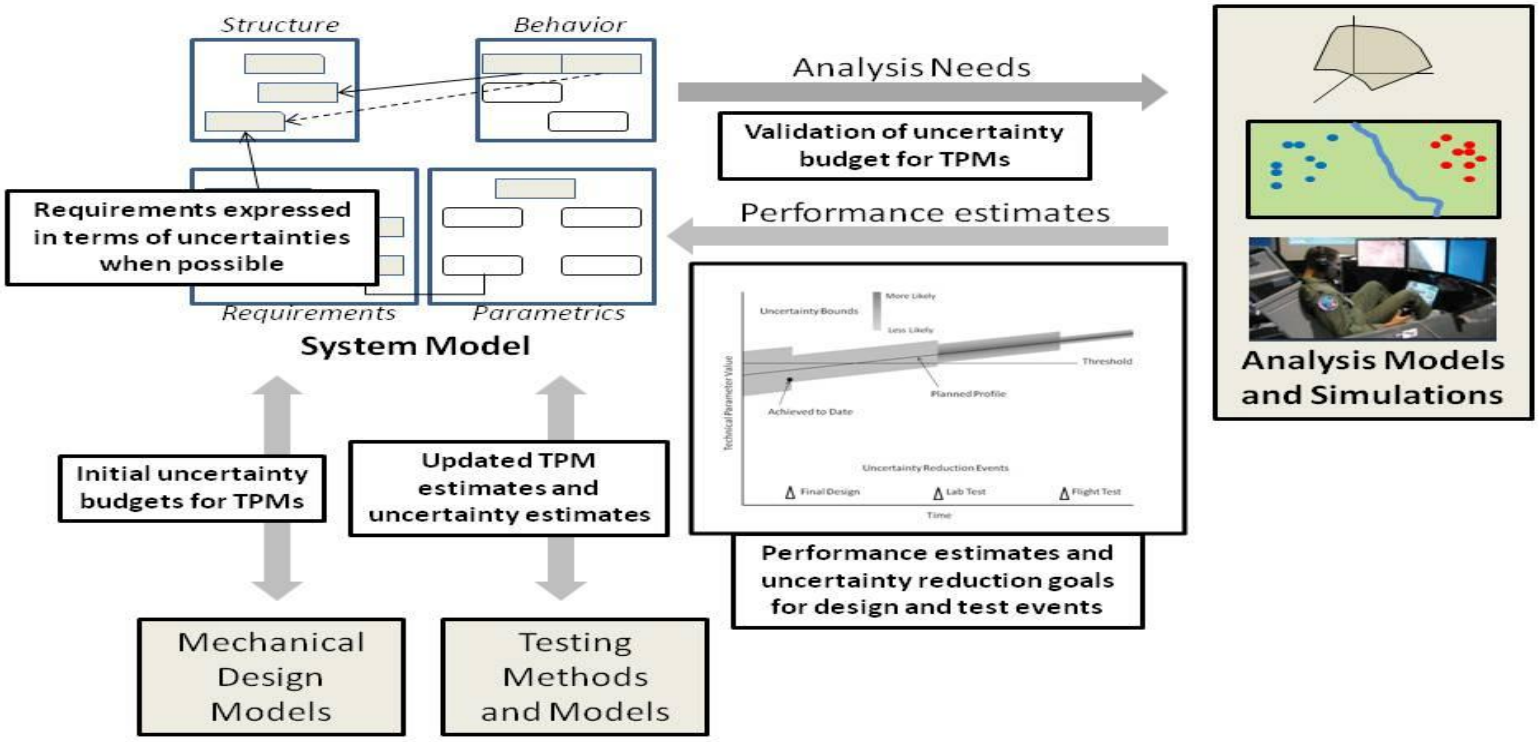
SoS Technical Performance Risk Index



- Provides integrated measures of technical performance
- Measures technical performance as a function of the physical parameters of the TPMs
- Measures the degree of risk and monitors change over time

Garvey, P.R. and Cho, C.C. (2004). "An Index to Measure and Monitor a System-of-Systems' Performance Risk", The MITRE Corporation.

MBSE Framework for T&E



- Uses MBSE framework and Monte Carlo Simulation to define uncertainty reduction goals for test planners to use in developing test strategies and detailed test designs for evaluating technical performance parameters
- Dr Bjorkman proposed a methodology to determine test value by estimating the amount of uncertainty reduction a particular test is expected to provide using Shannon's Information Entropy as a basis for the estimate

Bjorkman, E.A., Sarkarni, S., and Mazzuchi, T.A. (2012). "Using Model-Based Systems Engineering as a Framework for Improving Test and Evaluation Activities", Unpublished.

Observations

- Focus has been on cost and schedule; technical performance often an afterthought
- Recent emphasis on test planning and test design
  - Need to redirect and increase focus on test analysis and reporting
- Immature technologies still an issue
- T&E interests need to be injected up front
- Critical technical parameter risks should be primary intent of research
- What do we go from here?

Future Work

- Assess system's progress and maturity against critical technical parameters as documented in the TEMP
  - Integrate and quantify risk and uncertainty into CTPs
- Analyze and aggregate data using information theoretic approaches
  - Shannon's information entropy; entropy as a risk measure
- Use Model-based Systems Engineering (MBSE) to continuously track and update various readiness levels
- Extend uncertainty reduction and MBSE research by Dr. Bjorkman into CTP reporting
  - Roll values into a holistic decision making model
- Report decision making model at upcoming T&E conference and STAT Panel Meeting

Summary

- Need for critical technical performance risk index
  - Inject technology maturity and uncertainty
- SE and T&E communities need to collaborate on development and tracking of technical performance, specifically CTPs, per DoDI 5134.17
- T&E community needs to be involved as early as possible (pre-MS B)
- Keep moving forward with research….

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